



Acquiring 21st Century Blitzkrieg via Physic-Based Gaming

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Agenda



- ESP in Systems Engineering
- Whole System Trade Analysis
- Defense Acquisition University MindRover/ Dragonfly
 - MAJ Keena's MindRover Tradespace Analysis
- Conclusions



BLUF

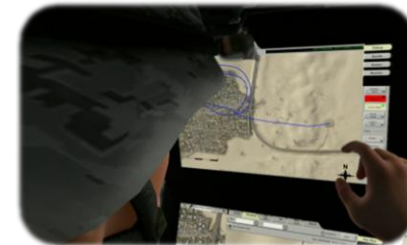


Finding the sweet-spot among competing objectives (performance, unit cost, O&S costs, development risk, and growth potential) is a non-trivial task. Ultimate metric is **affordable mission success**.



Ground vehicles are complex systems with many interrelated subsystems.

Matériel and Tactical Employment are not separable in real world.





Early Synthetic Prototyping



ARCIC Early Synthetic Prototyping (ESP)

- MG Hix tasked LTC Vogt to setup a persistent game environment for Soldiers to play emerging technologies.
 - ARCIC is looking for >20 year out concepts for the Army to try out in a gaming environment
 - End state: 1000 Soldiers in **persistent** environment
- Initially pursuing robotic wingman concept as pilot study
- First person shooter environment to start (VBS3 currently)

Random Fact: After one month of the release of Call of Duty Black Ops, gamers accumulated 68,000 years of play.



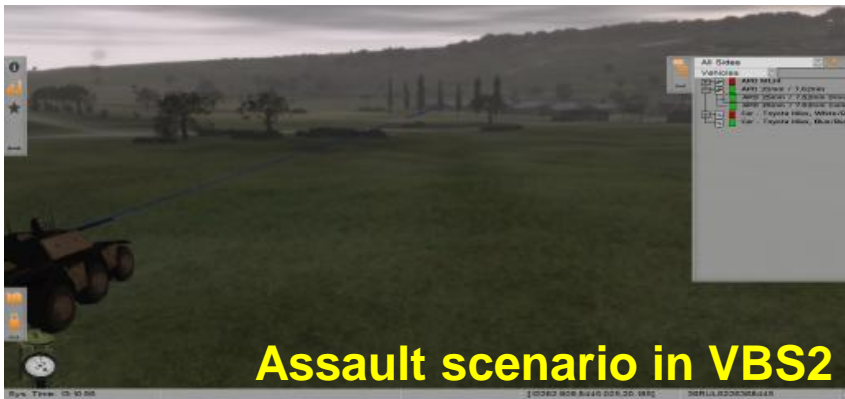


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Early Synthetic Prototyping NPS Pilot Study: Robotic Wingman



- Robotic wingman based on actual demonstrator system
- Three scenarios:
 1. Track a red convoy (AI) to a specific location, then eliminate it. 4 blue
 2. Assault a defended, fixed location to free prisoners. 2 blue/ 2 red
 3. Defend an urban location for five minutes. 2 blue/ 2 red



**Game Physics Based on
Autonomous Platform
Demonstrator**



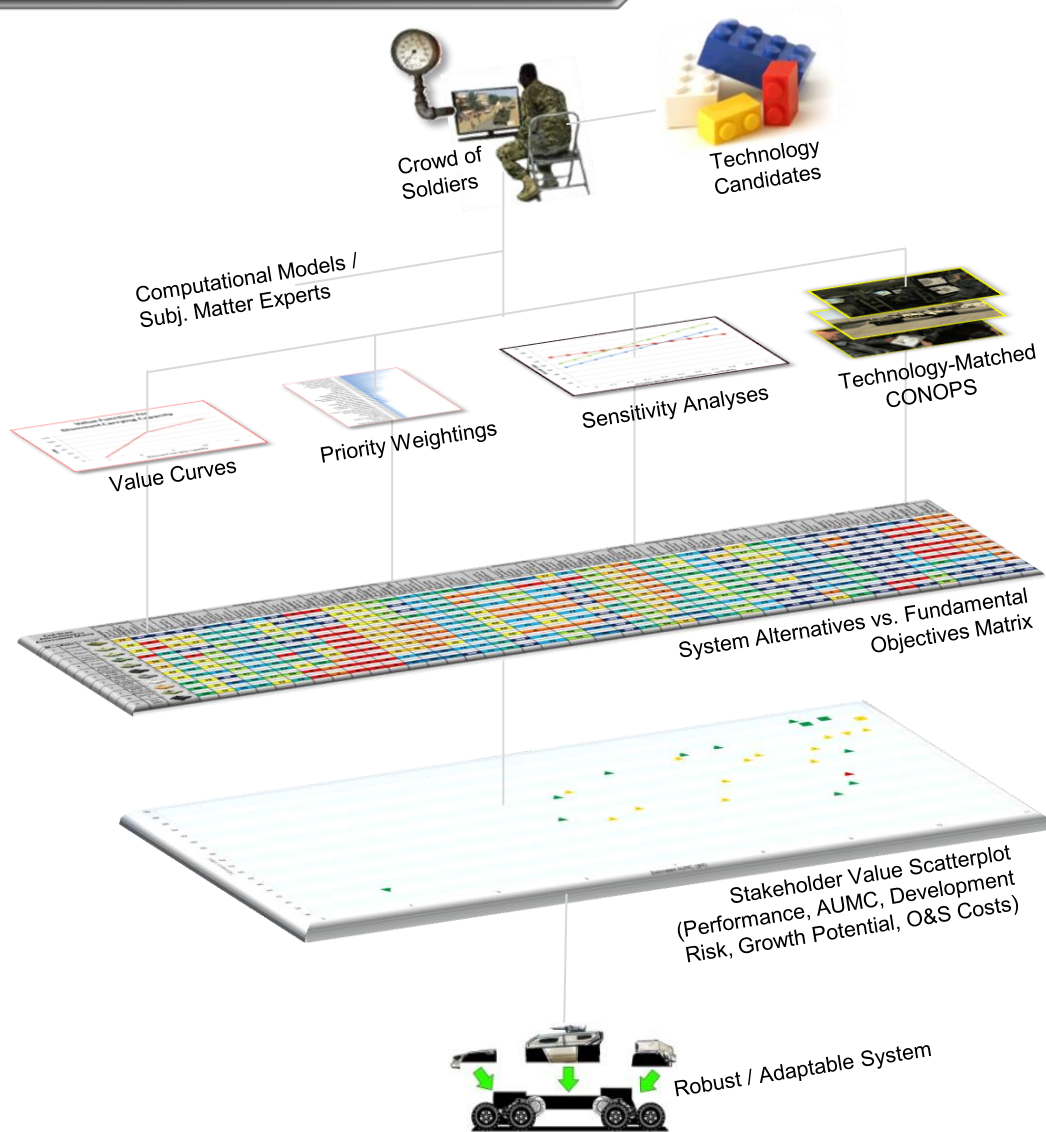
Big Takeaways:

- Soldiers very enthusiastic about playing game – especially head-to-head
- Game interface is very important (which key does what)
- Scenarios showed definite desire to tailor platform for mission

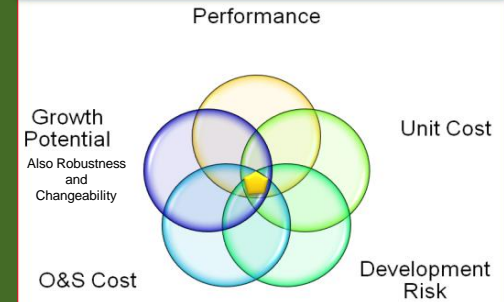


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Early Synthetic Prototyping: Systems Engineering Construct



Elements of Stakeholder Value

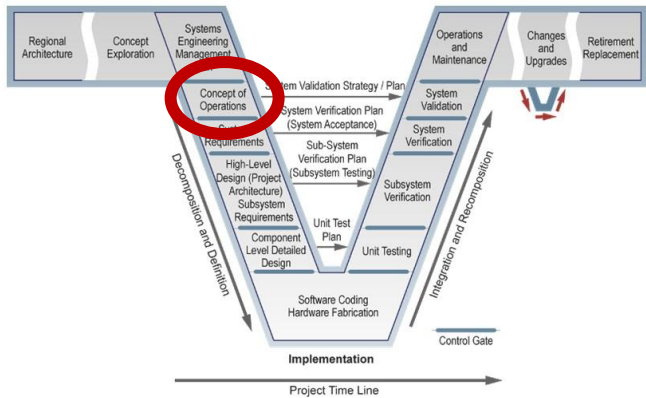


Capture and synthesize analyses being conducted by Soldiers AND subject matter experts into visualizations designed to facilitate rapid and complete understanding of the trade-space to stakeholders and provide drill down capability to supporting rationale.



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How do you develop a system if you do not know what it is supposed to do?



108 SE's surveyed:¹

- 36% never had CONOPS
- 73% did not complete CONOPS by program start
- 50% did not update CONOPS
- 30% did not involve a user

60 CONOPS examined:

- took 3-30 months to complete
- 25% did not state mission needs
- 80% did not discuss system risks
- 50% did not include operational scenarios
- 50% of IEEE or ANSI standard elements were not included

NOTE: CONOPS = Concept of Operation



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Value of Digital Combat vs. "Magazine Racing"



Magazine Racing: Where you pull out the specs and never run the race.

DATA Based: Maintenance, weather, driver tactics, trans type, component durability, run-to-run variation, etc

Camaro SS 2010

Engine: 6.2 Liter LS3
Power (SAE): 426 BHP @ 5900 RPM
Torque: 420 ft-lb @ 4600 RPM
Weight: 3,860 lbs

Mustang GT 2011

Engine: 5.0L V8
Power (SAE): 412 hp @ 6,500 rpm
Torque: 390 ft-lb @ 4,000 rpm
Weight: 3,605



Which solution is more robust
for the end result?



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Tactical Utility Concept



Major driver of **future** acquisitions is to maximize combat success at a minimal cost:

$$\text{Tactical Utility} = \text{Mission Success} / \text{Total Cost}$$

- Mission Success resiliency **quantified by game data**
- Total Cost = development, acquisition, future customization, maintenance, disposal

Future will bring tension between two extremes and solution robustness:

1. Mass produced, but adaptable / flexible via modularity
2. Custom specific purpose “disposable” vehicles



Closer Look at WSTAT Tradespace Exploration

Whole System Trade Analysis was developed by TACOM to identify relationship between high level design decisions & stakeholder value. Contact: Shatiel Edwards.

shatiel.b.edwards.civ@mail.mil



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Example Stakeholder Value Scatter Plot Window



Legend

Development Risk

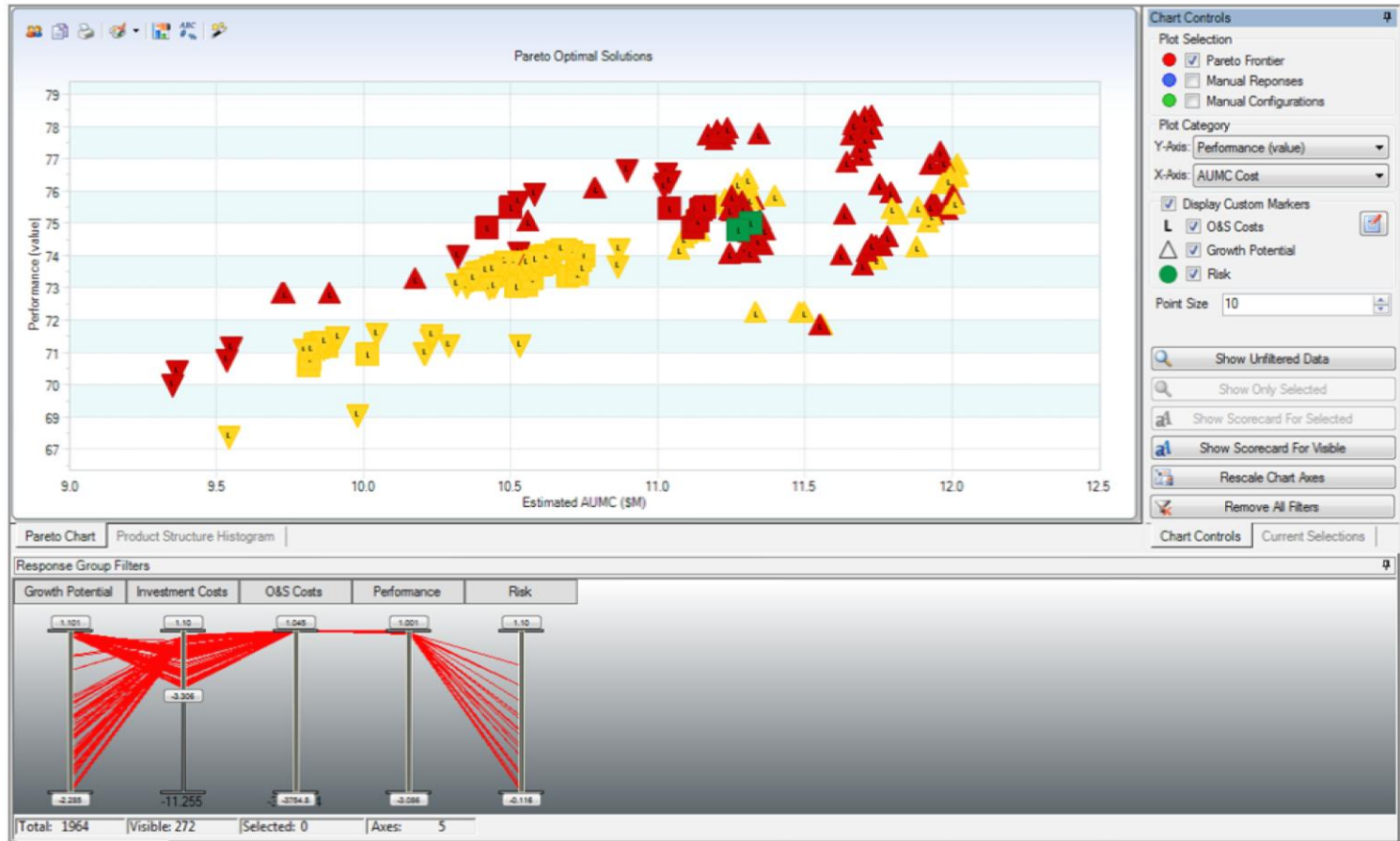
- High Risk
- Moderate Risk
- Low Risk

Growth Potential

- ▲ high growth potential
- moderate growth potential
- ▼ low growth potential

O&S Costs

- Ⓜ High O&S Costs
- Ⓜ Moderate O&S Costs
- Ⓜ Low O&S Costs

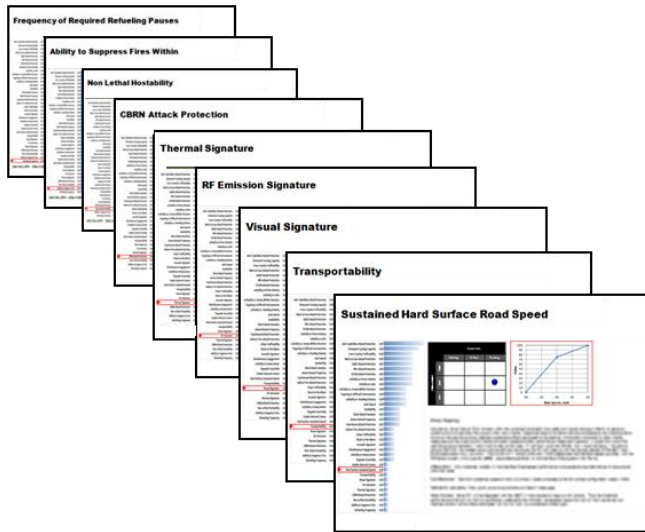


The stakeholder value scatterplot synthesizes data to show each system alternative's response in dimensions of stakeholder value (unit cost, O&S cost, performance, development risk, growth potential)



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Relative Feature Priority / Value Functions



Priority weightings and value functions for each objective are well reasoned based on SME input and gaming data.

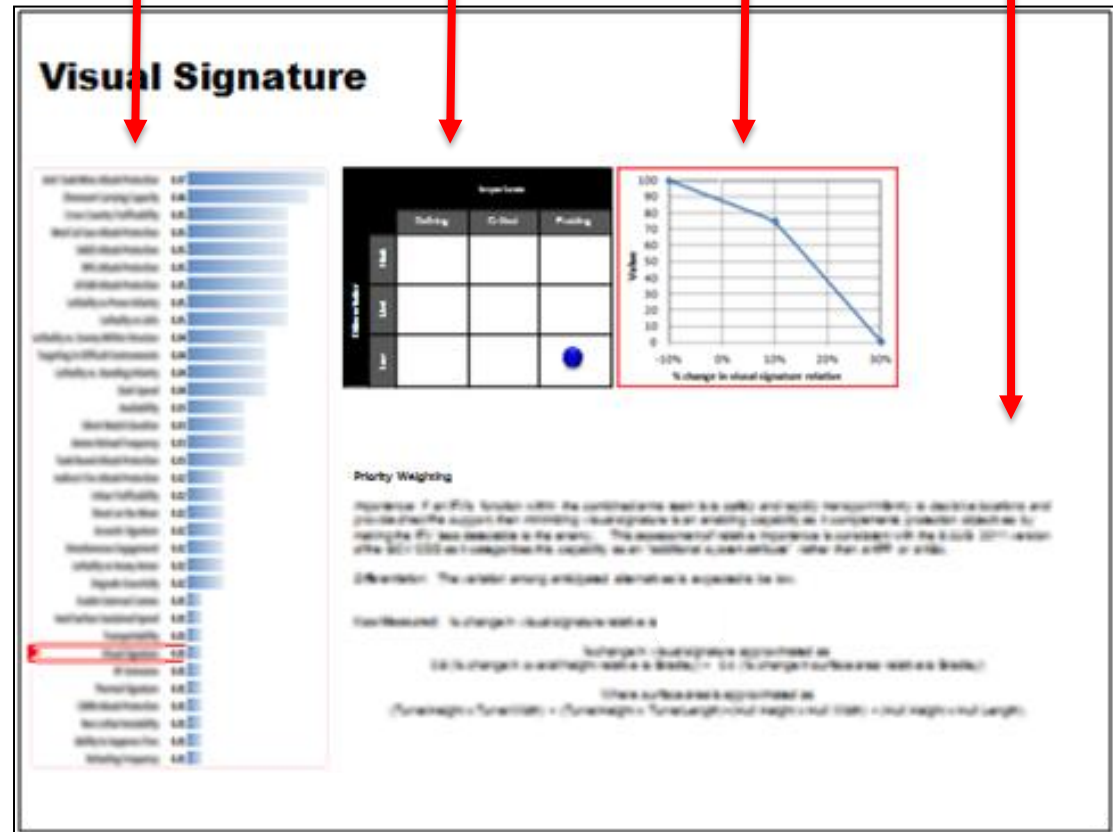
Relative Priority Weighting Indicator

Swing Weight Matrix

(Performance Gap vs. Importance)

**Value
Function**
(knee in the
curve)

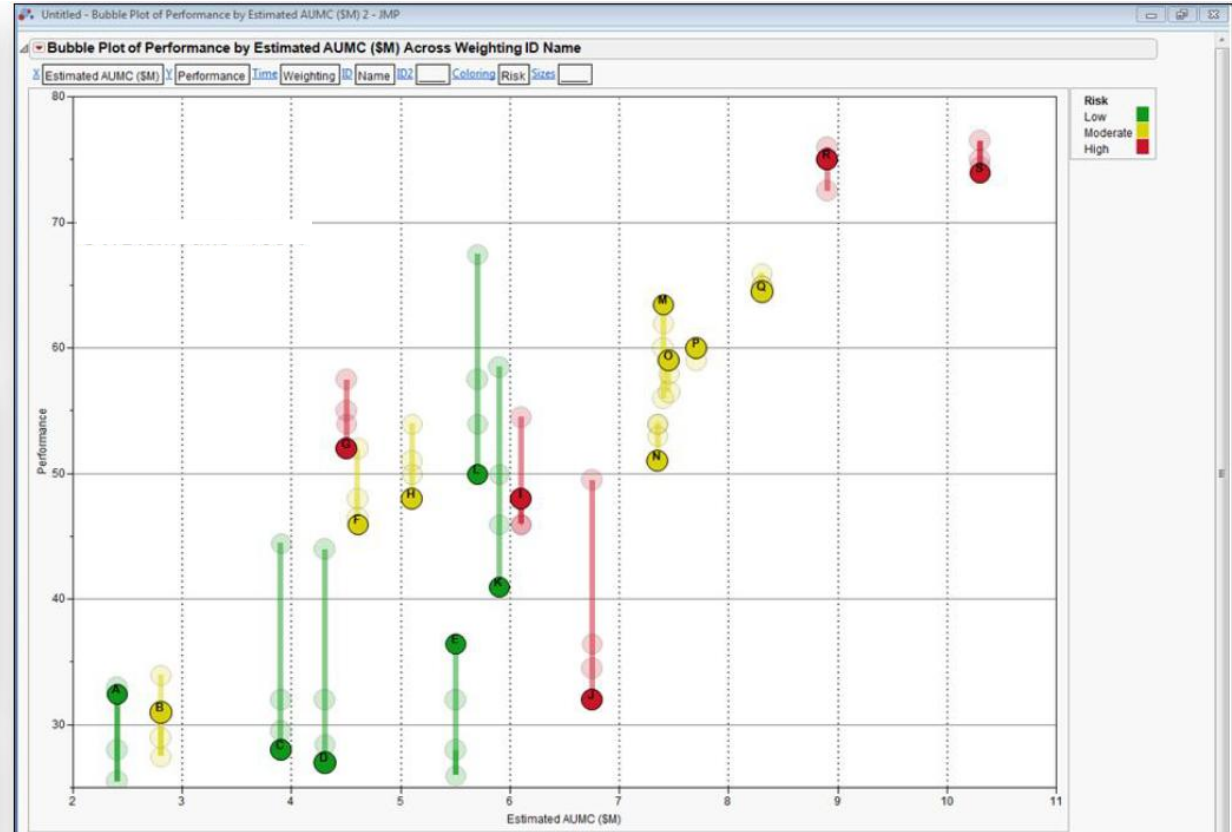
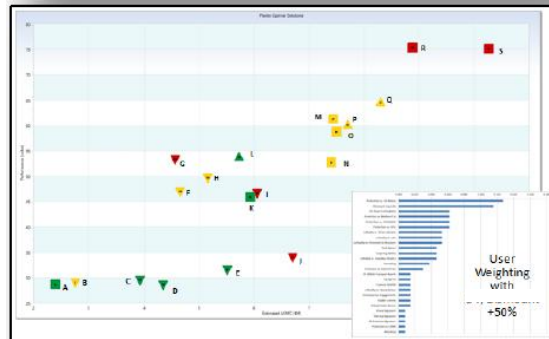
Supporting Narrative





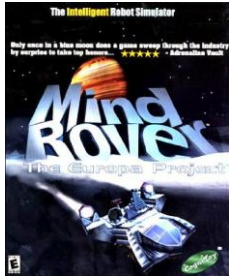
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Sensitivity Analysis



Sensitivity analysis allows decision makers to see how performance values for each alternative move as priority weightings change.

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ESP Crowdsourced Demonstrator: Defense Acquisition University's MINDROVER / DRAGONFLY



- PMT-352 Program Management teaching tool
- Ver 1: Mindrover based on commercial game
- Ver 2: Dragonfly simplifies the "wiring requirements" and tunes for teaching
- MAJ Keena example DOE using MindRover

JRATS = (Joint Reconnaissance and Targeting System) robotic combat vehicle

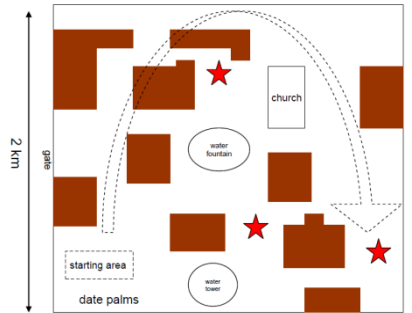


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Keena Study: Over 1400 MindRover Runs Using 14 ROTC Cadets



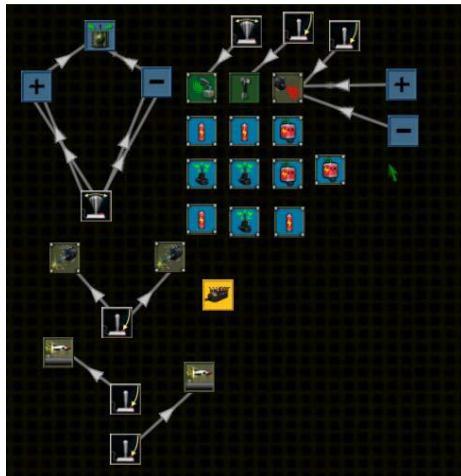
Move to Contact Urban Scenario



JRATS screenshot during contact. In this shot, the guided missile has drifted left of the laser and has missed the threat vehicle.



JRATS vehicle rendering of a completed tracked combat platform.



Design screen: Build components are placed on a virtual breadboard. Logic components and interface modules are wired together to form the functional combat platform prototype..

Very similar to SysML or DARPAs AVM META!



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Keena's Game Based Design of Experiments

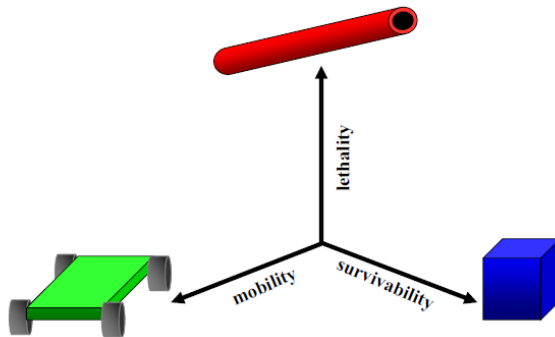


S	S
Acceptable Survivability	Enhanced Survivability
rolled homogeneous (steel) armor aluminum body	depleted uranium armor steel body

I	L
Acceptable Lethality	Enhanced Lethality
2× heavy machine gun laser range finder communications suite ground penetrating radar	2× guided missile pods 2× heavy machine gun laser range finder communications suite ground penetrating radar

m	M
Acceptable Mobility	Enhanced Mobility
low output powerplant aluminum frame	high output powerplant composite frame

- DOE with 18 variants
 - tracked vs wheeled
 - survivability 2 levels
 - lethality 2 levels
 - mobility 2 levels
 - 2 training vehicles
- 14 Operators
 - 15 missions per randomly assigned variants
 - Result= ~100 missions per vehicle
- 1600 ground vehicle missions



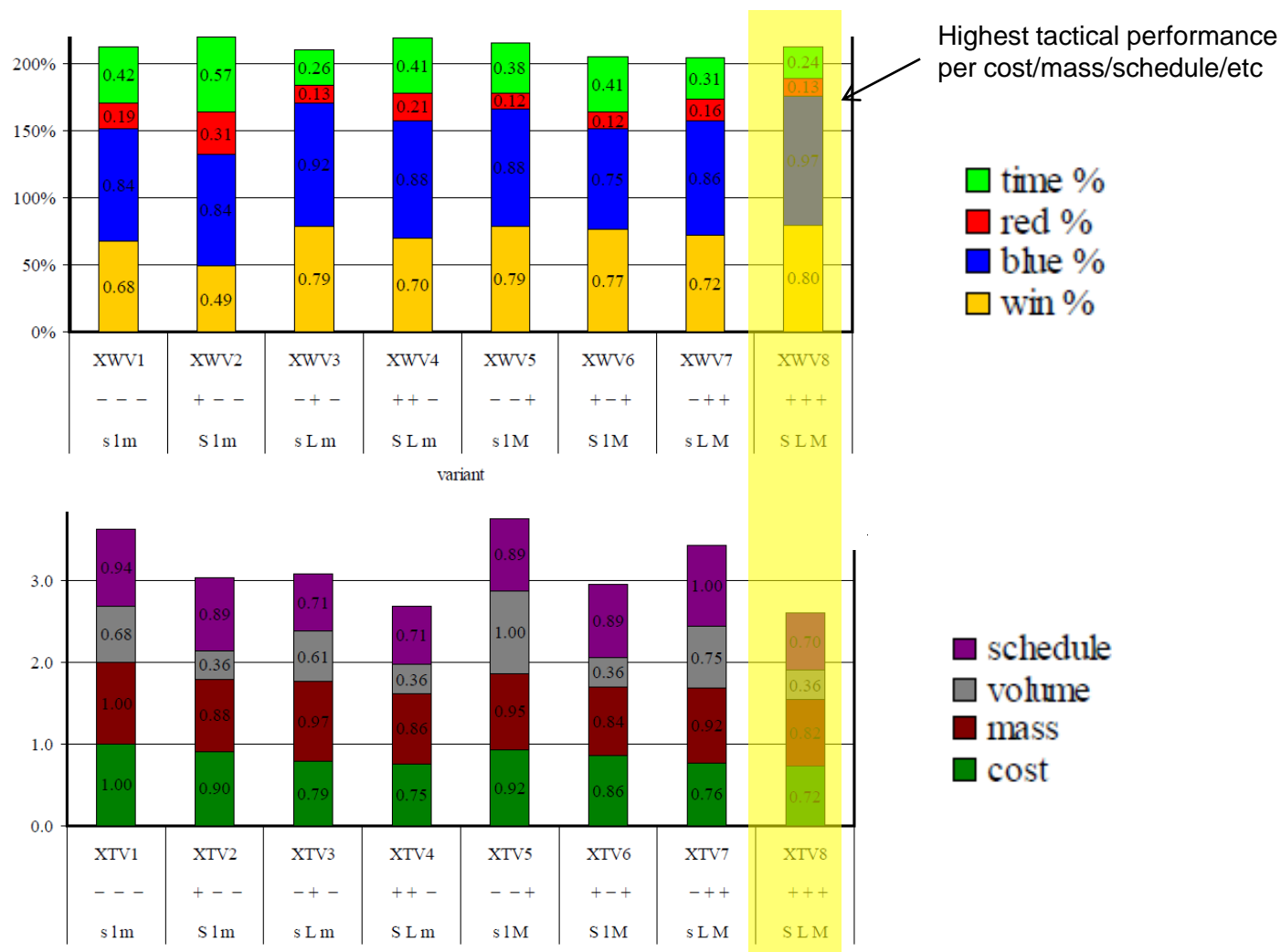
OUTPUT METRICS:

- rating of success or failure
- elapsed mission time (time mission)
- the friendly vehicle's remaining health (blue mission %)
- and threat vehicle's remaining health (red mission %)



Example Output Data

(Could be weighted/ normalized multiple ways)





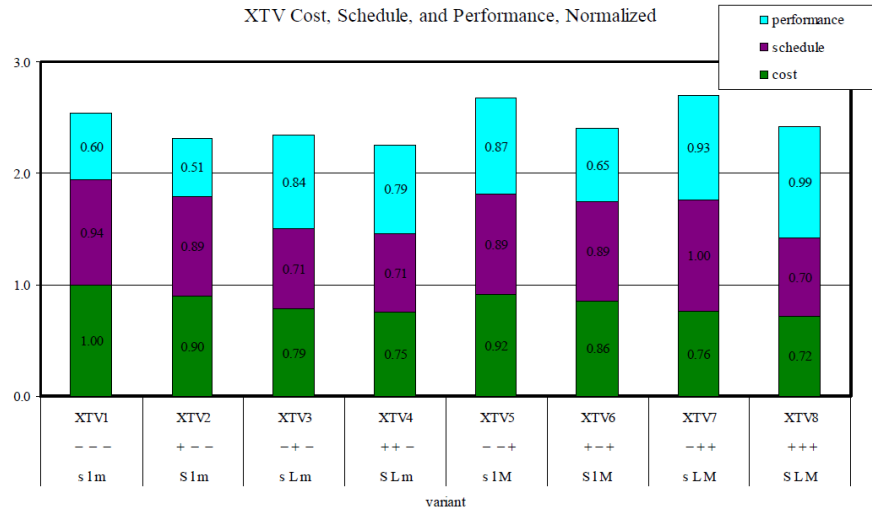
Example Output Data

(Here's normalized performance, schedule, and cost)



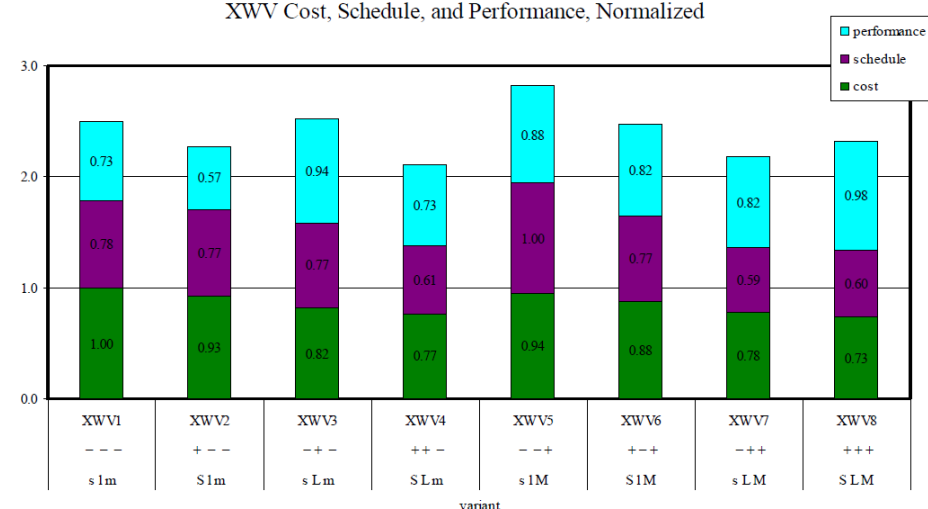
Tracked

XTV Cost, Schedule, and Performance, Normalized



Wheeled

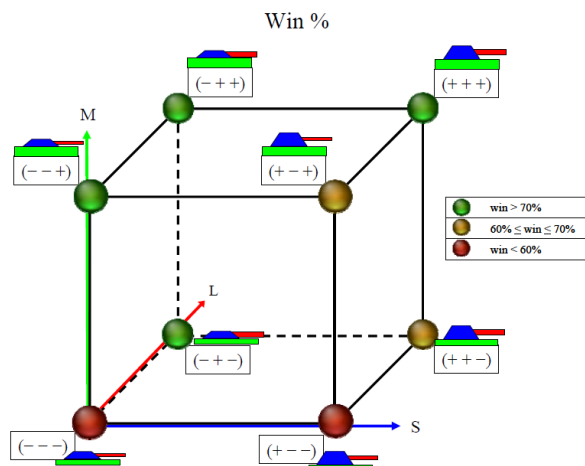
XWV Cost, Schedule, and Performance, Normalized



Performance is the sum of the normalized values for variant win %, blue %, red %, and time % divided by the number of *a posteriori* metrics (4). Cost is the per vehicle cost normalized with respect to the variant with the lowest per vehicle cost. Schedule is the normalized schedule index with respect to the variant with the lowest schedule index.



Relative Contributions and Interactions of Survivability, Lethality, and Mobility on Ground Combat Vehicle Performance



Average variant win record (XTV and XWV) in a survivability, lethality, and mobility domain. An XTV and XWV variant coincident at a point share the same relative levels of survivability, lethality, and mobility.

	Win % [%]	Blue % [%]	Red % [%]	Time % [%]
XTV	L 26	L 9	L 15	L 19
	M 19	S 2	M 13	M 12
	S 10	M 1	S 10	S 1
XWV	M 14	L 8	M 8	L 14
	L 8	S 2	S 4	M 8
	S 7	M 1	L 3	S 7

Effects of principal attributes on *a posteriori* performance metrics for XTVs and XWVs. A red bar indicates a negative effect on the metric, and a green bar indicates a positive effect on the metric. The length of the bar has been scaled in length with respect to the greatest effect for that metric in the XTV or XWV block.

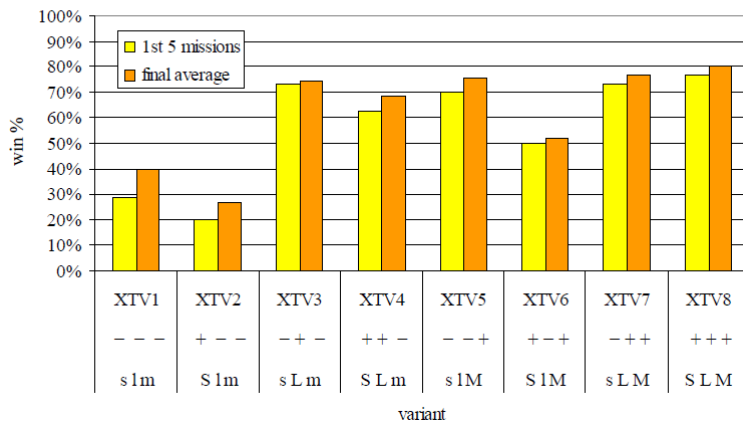


Learning Rate Vs. AI

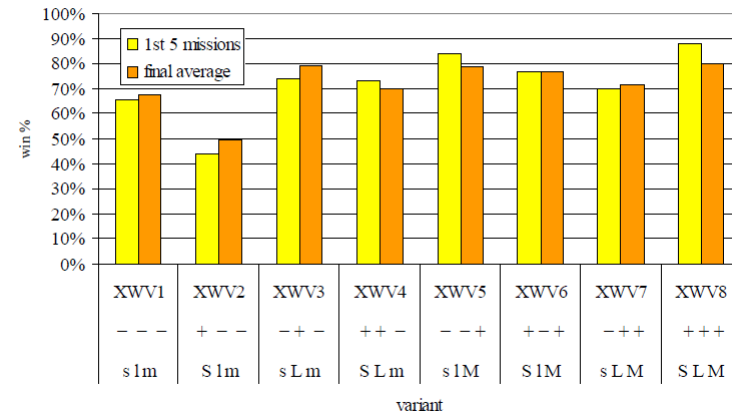


- During training sessions group discussed tactics, techniques, and procedures (TTPs)
- Training missions conducted on tracked and wheeled training vehicle variants (TTV and TWV)
- Operators instructed to move in a clockwise fashion until the enemy vehicle was spotted
- Non-training sessions Win % calculated after just 5 missions versus final average at 15 missions per operator

TRACKED



WHEELED



- Enhanced survivability platform had the greatest learning curve
 - Variant had the lowest mobility performance, with no gain in lethality
 - Operators presumably struggled initially to maneuver around the city
- Aside from the baseline variant (XTV1), all other variants had a learning curve less than 3%.

- Enhanced survivability platform had the greatest learning curve
 - Variant had the lowest mobility performance, with no gain in lethality
 - Operators presumably struggled initially to maneuver around the city
- Degradation in performance over time was seen for some variants
 - XWV8 experienced an over 5% drop in win % from first five to final 15 average
 - Possibly elevated baseline mobility enhanced even more for XWV5 and XWV8, caused operators to move in an ineffective or more "sloppy"
 - Suggests that the platform performance is directly effected by operators.

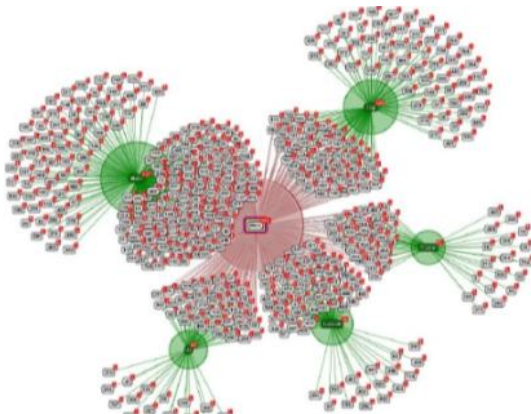
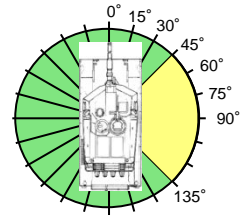


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What Other Useful Metrics Might be Collected From Game Analytics?

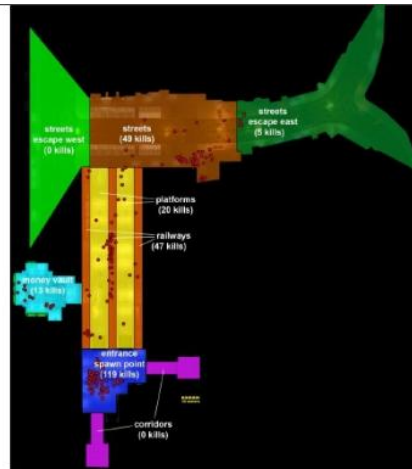


- Replays of winning tactics (directly obtained CONOPS)
- Discussion board chatter
- Sector engaged from in azimuth around vehicle
- Rounds expended
- How much available power and speed actually used



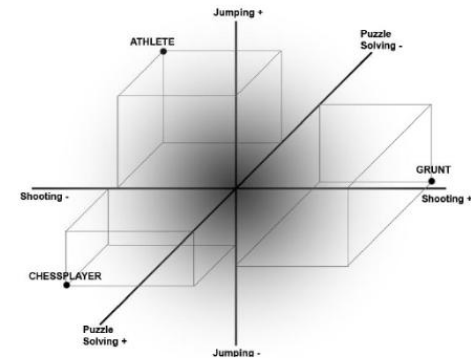
Flower of Death

Generated by a cluster visualization tool (shows data from *Fragile Alliance*, it relates **role** at death with **cause** of death)



Deaths in Sectors

Plotted deaths divided per sub-sector



Play persona possibility space

Mapping the possibility space with play-personas



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Enough Game Data Allows The Teasing Apart of Modularity and Customization Needs

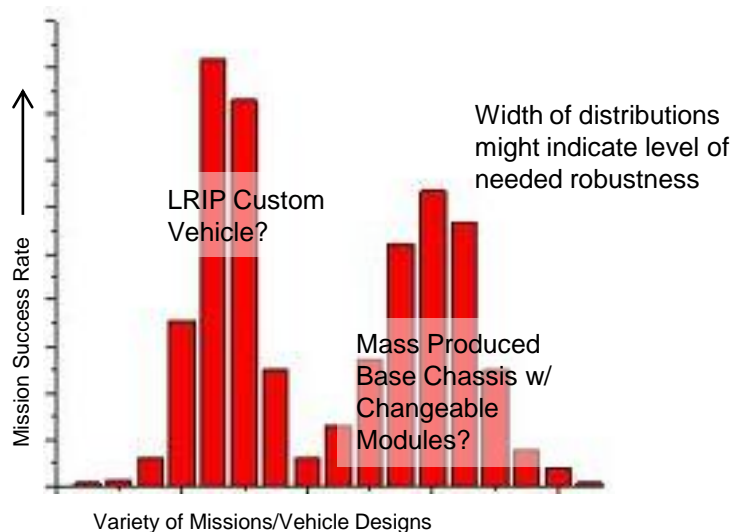
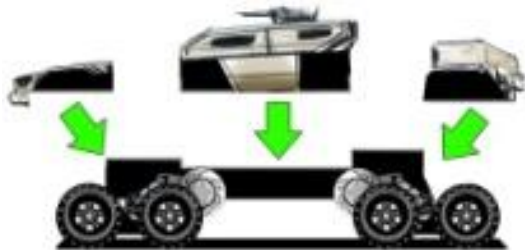


Which configuration elements can remain constant?

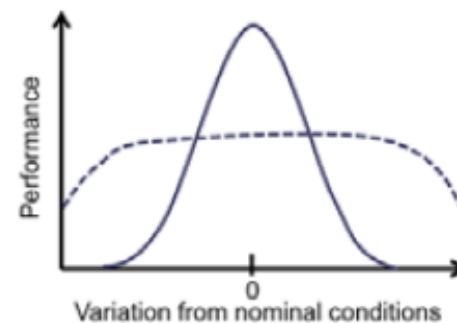
Which things need to be made modular?

Can a whole custom system be fabricated less expensively than a changeable system?

How robust is the solution in different scenarios?



Fitness: Optimality vs. Resilience



Defense Acquisition University's DRAGONFLY Screenshots



- Dragonfly simplifies the “wiring requirements” and tunes for teaching
- Gives some clues as to complexity in a game for acquisitions



DragonFly ScreenShots (Formerly MindRover)





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Parameters Tracked in Dragonfly



Chassis	FRACU	Scorpion	Mole
Vehicle Type	Hover	Tracked	Wheeled
Vehicle Size	Small	Medium	Large
Engine Size	Small	Medium	Large
Frame	Aluminum	Aluminum	Titanium
Armor	None	None	Steel

Power	Qty	Type	Qty	Type	Qty	Type
	3	Mk-III Batteries	1	Mk-V Battery	2	Mk-IV Generators
			1	Mk-III Fuel Cell	1	Mk-I Battery
			1	Mk-IV Generator		

Electronic Components	Qty	Type	Qty	Type	Qty	Type
	1	Mk-I Targeting Laser	1	Mk-IV Targeting Laser	1	Mk-IV Targeting Laser
	1	Mk-I Radio Transmitter	1	Mk-IV Radio Transmitter	1	Mk-IV Radio Transmitter
	1	Mk-I Linear Mine Detector	1	Mk-V Linear Mine Detector	1	Mk-IV Hemispherical Mine Detector
	1	Mk-I Radar	1	Mk-I Radar	1	Mk-IV Radar
	1	Mk-I Targeting Computer	1	Mk-I Targeting Computer	1	Mk-IV Targeting Computer
			1	Mk-IV Electronic Countermeasure	1	Mk-IV Electronic Countermeasure

Weapons	Qty	Type	Qty	Type	Qty	Type
	1	Mk-I Mini Gun	1	Mk-I Machine Gun	2	Mk-IV Mini Guns
	1	Mk-I Laser Guided Missile	1	Mk-I Laser Guided Missile	1	Mk-IV Free Rocket
			1	Mk-I Multi-Shot Free Rocket	1	Mk-IV Multi-Shot Free Rocket

Properties	FRACU	Scorpion	Mole
Weight (kg)	1266	1485	2029
Combat Survivability	230	275	410
Idle Power (watts)	35	58	59
Active Power (watts)	97	135	142
Produced Power (watts)	105	135	125
Acceleration (m/sec ²)	8	7	9
Top Speed (kph)	25	14	30
Length (m)	2.25	3	3
Logistics Supportability Index (LSI)	2866	3085	3629
Deployability Index (DI)	1741	1960	2504
Producibility Index (PI)	830	875	1010

Costs	FRACU	Scorpion	Mole
Development	\$41M	\$60.5M	\$86.5M
O&S	\$1230M	\$1710M	\$2370M
Procurement	\$615M	\$855M	\$1185M
Unit Procurement	\$0.41M	\$0.57M	\$0.79M
Disposal	\$61.5M	\$85.5M	\$118.5M
MILPERS	\$184.5M	\$256.5M	\$355.5M
Total	\$2132M	\$2967.5M	\$4115.5M



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DragonFly ScreenShots



DRAGONfly STUDENT VERSION

MAIN MENU

NEW VEHICLE

EDIT VEHICLE

FIELD TEST

MULTIPLAYER

SETTINGS

EXIT PROGRAM



DragonFly ScreenShots



DESIGN MODE: VEHICLE CREATION



NOTE: CLICK AND DRAG TO ROTATE VEHICLE

CHOOSE VEHICLE TYPE



WHEELED



TRACKED



HOVER

CHOOSE VEHICLE SIZE

SMALL

MEDIUM

LARGE

VEHICLE DATA

COMPONENT SLOT CONFIGURATION



FRONT

== Chassis Performance Statistics ==

Weight: 890 kgs
Survivability: 230
Idle Power: 25 Watts
Active Power: 32 Watts
Produced Power: 0 Watts
Acceleration: 8 m/s²
Top Speed: 25 kph
Length: 2.25 m
Logistics Index: 1600
Deployability Index: 475
Producibility Index: 600

== Vehicle Cost Statistics ==

Development Cost: \$18M
Operations And Support Cost: \$480M
Procurement Cost: \$240M
Unit Procurement Cost: \$0.48M
Disposal Cost: \$24M
MIL PERS Cost: \$72M

Total Cost: \$834M

== Chosen Chassis Options ==

Vehicle: Small Hover
Engine: Small Engine
Frame: Aluminum Frame

MAIN MENU

PRINT

✓ CREATE VEHICLE



DragonFly ScreenShots



DESIGN MODE: CHASSIS OPTIONS

ENGINE SIZE



SMALL



MEDIUM



LARGE

Small Engine Statistics:
Weight: 715 lbs
Survivability: 180
Idle Power: 10 Watts
Active Power: 12 Watts
Max Speed: 12 m/s
Acceleration: 6 m/s²

Development Cost: \$10.5M
Operations And Support Cost: \$280M
Procurement Cost: \$140M
Unit Procurement Cost: \$0.20M
Planned Cost: \$1.12M

FRAME MATERIAL



ALUMINUM



COMPOSITE



TITANIUM

Aluminum Frame Statistics:
Weight: 210 lbs
Survivability: 75
Max Weight: 5000 lbs

Development Cost: \$13.5M
Operations And Support Cost: \$380M
Procurement Cost: \$180M
Unit Procurement Cost: \$0.35M
Disposal Cost: \$18M
MIL PERS Cost: \$54M
Total Cost: \$1.12M

ARMOR TYPE



NONE



STEEL



TUNGSTEN

No Armor Statistics:
Weight: 0 lbs
Survivability: 0

Development Cost: \$0M
Operations And Support Cost: \$0M
Procurement Cost: \$0M
Unit Procurement Cost: \$0M
Disposal Cost: \$0M
MIL PERS Cost: \$0M
Total Cost: \$0M

VEHICLE DATA

■ IDLE POWER ■ MAX POWER

POWER AVAIL.

WEIGHT LIMIT

Chassis Performance Statistics

Weight: 925 lbs
Survivability: 255
Idle Power: 32 Watts
Active Power: 38 Watts
Produced Power: 0 Watts
Acceleration: 6 m/s²
Top Speed: 12 kph
Length: 3 m
Logistics Index: 1600
Deployability Index: 475
Producibility Index: 600

Vehicle Cost Statistics

Development Cost: \$24M
Operations And Support Cost: \$640M
Procurement Cost: \$320M
Unit Procurement Cost: \$0.64M
Disposal Cost: \$32M
MIL PERS Cost: \$96M
Total Cost: \$1112M

MAIN MENU

PRINT

SAVE VEHICLE

CUSTOMIZE CONTROLS

▶ SELECT COMPONENTS

⏻ LAUNCH TEST



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Vehicle Configuration



DESIGN MODE: COMPONENT SELECTION



NOTE: RIGHT CLICK TO CHANGE MARK NUMBER

POWER

ELECTRONICS

WEAPONS



VEHICLE DATA

PREVIEW

☐ IDLE POWER ☒ MAX POWER

POWER AVAIL.

WEIGHT LIMIT

Vehicle Description:
The hovercraft is able to traverse water, giving it a distinct terrain advantage over the other vehicles. However, it has a low durability and cannot carry as much weight as the other vehicles. The hovercraft has the most component slots of the chassis types and is capable of rapid rotation and agile movement, making it ideally suited to recon missions or when you need to dodge incoming fire.

SELECTED COMPONENT



Laser-Guided Missile

Weight 44 lbs
Active Power 8 Watts
Idle Power 1 Watts
Damage 80
Ammo 35 rounds
Reattachment Cost 400 CTS

MAIN MENU

PRINT

SAVE VEHICLE

CUSTOMIZE CONTROLS

◀ CHASSIS OPTIONS

⏻ LAUNCH TEST

UNCLASSIFIED



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TECHNOLOGY DRIVEN. INNOVATION FOCUSED.

Virtual Field Test



HEALTH

POWER

Press 'M' to toggle Map
Press 'TAB' to return to
design mode.

Button 3

Button 2

Button 8

OFF ON

Button 1

OFF ON

Button 6

OFF ON

Button 5

OFF ON

Button 7

OFF ON

NNE NE ENE E

MISSION TIME
07:01

Vehicle Test

INTEROP ACTIVE

INTEROP PASSIVE

MINE DETECTION

SEEK AND DESTROY PASSIVE

SEEK AND DESTROY ACTIVE

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"Mission Load" screen for "Field Test" test mode



MISSION LOAD



BRIEFING

Seek & Destroy (Passive)

The students must locate and destroy 3 moving AI and 1 target building. The AI would not be hostile.

SELECT MISSION

SUCCESS/ ATTEMPTS	MISSION TYPE
0/0	SEEK & DESTROY (PASSIVE)
0/0	SEEK & DESTROY (ACTIVE)
0/0	INTEROPERABILITY (PASSIVE)
	SINGLE FIREBIRD
	AC-130
	MULTIPLE FIREBIRDS
0/0	INTEROPERABILITY (ACTIVE)
	SINGLE FIREBIRD
	AC-130
	MULTIPLE FIREBIRDS
0/0	MINE DETECTION

[MAIN MENU](#)[VIEW REPORTS](#)

[Start the selected Mission](#)
START MISSION



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Field Reports



REPORT LIST

Mine Detection

Seek and Destroy - Passive

05-23-2010, 12:22:56

05-23-2010, 12:26:06

Seek and Destroy - Active

Interoperability - Passive

Interoperability - Active

PRINT SELECTED

PRINT ALL

◀ BACK

FIELD REPORTS

Seek and Destroy - Passive 05-23-2010, 12:26:06

Start Time:	05-23-2010, 12:26:06
Elapsed Time:	07:40
Remaining Time:	07:20
Successfully Completed:	yes
Player Health:	100%
Enemy Vehicle 1 Health:	0%
Enemy Vehicle 2 Health:	0%
Enemy Vehicle 3 Health:	0%
Enemy Building Health:	0%

SUMMARY

The students must locate and destroy 3 moving AI and 1 target building. The AI would not be hostile.



Conclusions



- Pilot studies indicate it is possible to get useful data from virtual combat (i.e. games)
 - Have only scratched the surface on true utility of this
- 21st Century Blitzkrieg requires tactics and materiel be tightly coordinated
 - Alternative is 21st century Maginot Line
- Crowdsourced gaming might provide enough data to allow acquisitions to understand growth, modularity, and maybe custom vehicle needs
 - Maximize tooth, minimize tail